BALLAST WATER TREATMENT SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 60/426,803, filed November 18, 2002.

FIELD OF THE INVENTION

[0002] The invention is directed generally to water treatment systems, and more particularly, to ballast water treatment systems usable on vessels.

BACKGROUND

[0003] Vessels, such as ships and megayachts, include ballast tanks for controlling the attitude of the vessels in a water body. For instance, cargo ships are designed to operate safely while carrying a full load. Ballast tanks are used to account for situations when a vessel has only a partial load or no load at all. Without ballast tanks, a vessel without a load would float too high in the water, thereby making the vessel unstable. Ballast tanks are contained in a vessel and receive water from a water body in which the vessel is floating. The ballast tanks are typically located in strategic locations to properly balance a vessel.

[0004] Often times, a ship loaded with cargo will arrive at a port and off load some or all of its cargo. Water is often drawn into the ballast tanks to compensate for the loss of cargo. The ship typically then journeys to a distant port to deliver remaining cargo. If the ship takes on additional fuel or cargo at the distant port, the ship releases some or all of the

ballast water at the distant port. Otherwise, the ship would be carrying too much weight. The ballast water typically contains contaminants such as, chemicals, suspended solids, fecal coliforms, nonnative biota, and other material that can harm the waters of the distant port.

[0005] Researchers at universities and independent organizations around the world have identified ballast water discharges as one of the leading causes of the decline in coral reefs throughout the tropics. In addition, ballast water has been suspected of being the cause of introduction of nonnative organisms to waters in which nonnative organisms have caused the extinction of indigenous animals. Thus, there exists an urgent need for a water treatment system usable on a vessel for treating ballast water by reducing the concentration of contaminants below an acceptable threshold, thereby allowing ballast water to be discharged overboard without causing adverse effects to the ecosystem in which the ballast water is discharged.

SUMMARY OF THE INVENTION

[0006] This invention is directed to a ballast water treatment system for removing one or more contaminants from ballast water on a vessel such as, but not limited to, a ship, megayacht, or other vessel. Such a system is needed because often times a vessel takes in ballast water and travels hundreds or at, times, thousands of miles before releasing the ballast water. Releasing the ballast water in another water body may result in the release of non-native organisms, which may negatively affect the native biota and, in an worst case scenario, may drive one or more populations of native organisms to extinction.

[0007] Components forming the ballast water treatment system may be modular in design to enable easily installation on vessels in space limited compartments. The ballast water treatment system may remove at least a portion of suspended solids, BODs, CODs, any combination thereof, or other materials, from the ballast water using a combination of treatment systems. The ballast water treatment system may inject disinfectants, such as, but not limited to, chlorine, bromine, and other halides, hydrogen peroxide, or other disinfectants, into the ballast water and may inject one or more ionized gases into the ballast water. One or more of the disinfectants may be generated from saltwater using a disinfectant generator. In at least some embodiments, the ionized gases may be produced onboard a vessel in which the ballast water treatment system resides using an ionized gas generator.

[0008] The ballast water treatment system may include a filtration system for removing contaminants from the ballast water. The filtration system may include coarse filters and fine filters, which may be capable of removing particles as small as 50 microns and smaller. The filtration system may be used to filter ballast water as the ballast water is sent into the ballast water tank and discharged from the ballast water tank.

[0009] The ballast water treatment system may also include a disinfectant system for injecting one or more disinfectants into the ballast water. The disinfectant system may include one or more disinfectant injectors for injecting at least one disinfectant into the ballast water. In at least one embodiment, the disinfectant system may generate disinfectants from saltwater using a disinfectant generator. The disinfectant generator may be formed from one or more conduits adapted to expose saltwater to electricity to induce electrolysis. Each conduit may have an electrical cell for applying an electrical charge to

the fluid flowing through the conduit, which, in at least one embodiment, is saltwater. Each conduit may also include one or more sensors for determining the pressure, temperature, and other system parameters. The disinfectant generator may be coupled to an inlet in the hull of a vessel for receiving water from the water body in which the vessel is floating. The water may be drawn from the water body and passed through the disinfectant generator, where one or more disinfectants may be removed from the water. The water may then be returned to the water body.

[0010] The ballast water treatment system may also include an ionized gas injection system for injecting one or more ionized gases into the ballast water. The ionized gas injection system may include one or more ionized gas injectors for injecting ionized gas into the ballast water. Ionized gas may be supplied by one or more ionized gas generators for generating ionized gas to inject into the ballast water passing through the system. The ionized gas generator may be formed from one or more chambers, whereby the chambers may include one or more ultraviolet lamps and one or more magnets. In at least one embodiment, the ionized gas generator may include a plurality of ultraviolet lamps that surround a plurality of magnets positioned generally along a longitudinal axis of a chamber. The magnets may be positioned so that ends of adjacent magnets have like polarity, which may widen the magnetic field cast by the magnets. A gas, such as, but not limited to air, may be passed through the ionized gas generator to produce ionized gases.

[0011] The ballast water treatment system may also include one or more mixers for mixing the disinfectants and the ionized gases with the ballast water. In at least one embodiment, the mixer may be used to inject the ionized gases into the ballast water. The

mixer may be formed from a generally cylindrical tube having a plurality of injectors. The injectors may be positioned around the perimeter of the mixer or in another configuration.

[0012] The ballast water treatment system may operate by filtering water before it has been deposited into the ballast water tank to remove contaminants from the ballast water before the contaminants have an opportunity to collect in the ballast water tank. The filtration system may also be used to filter the ballast water as the ballast water is discharged from the ballast tank and passed through other components of the ballast water treatment system. The ballast water may also be mixed with one or more disinfectants. The disinfectants may be generated from saltwater using a disinfectant generator, and the byproducts generated may be disposed overboard. The ballast water may also be mixed with one or more ionized gases. The ionized gases may be generated from air using an ionized gas generator. The ionized gases may be mixed with the mixture of ballast water and disinfectants in the mixer. The ballast water may be tested to determine whether the ballast water has a concentration of contaminants less than a predetermined threshold. If the concentration of contaminants is less than the threshold, the ballast water may be discharged overboard. Otherwise, the ballast water may be passed through a recirculation loop and passed back through the ballast water treatment system.

[0013] An advantage of this system is that ballast water treatment system may remove one or more contaminants from ballast water before the ballast water is discharged overboard, thereby reducing the negative side effects associated with discharging contaminant laden ballast water overboard.

[0014] Another advantage of this system is that the system uses relatively small amounts of chemicals to disinfect ballast water and leaves little residual chemicals in the ballast water emitted from the system.

[0015] Yet another advantage of this invention is that the system does not require that volatile chemicals be stored in tanks on board a vessel; rather, the disinfectants may be removed from saltwater and the byproducts be discharged overboard. Thus, the dangers associated with storing volatile chemicals may be eliminated.

[0016] These and other features and advantages of the present invention will become apparent after review of the following figures and detailed description of the disclosed embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The accompanying drawings illustrate embodiments of this invention and, together with the description, disclose various aspects of the invention. These figures include the following:

[0018] Figure 1 is a schematic diagram of an embodiment of the ballast water treatment system;

[0019] Figure 2 is a cross-sectional view of a filter usable in the ballast water treatment system;

[0020] Figure 3 is a side view of a disinfectant generator usable in the ballast water treatment system;

[0021] Figure 4 is an end view of the disinfectant generator shown in Figure 3;

[0022] Figure 5 is a side view of internal components of the disinfectant generator shown in Figure 3;

[0023] Figure 6 is a cross-sectional side view of an ionized gas generator usable in the ballast water treatment system;

[0024] Figure 7 is a cross-sectional end view of the ionized gas generator shown in Figure 6;

[0025] Figure 8 is a cross-sectional side view of the ionized gas generator taken at 8-8 in Figure 6;

[0026] Figure 9 is a side view of a collection of chambers forming an ionized gas generator;

[0027] Figure 10 is a front view of the collection of chambers forming an ionized gas generator shown in Figure 9;

[0028] Figure 11 is a side view of a mixer usable in the ballast water treatment system;

[0029] Figure 12 is a cross-sectional side view of a portion of the mixer of Figure 11; and

[0030] Figure 13 is a cross-sectional top view of a portion of the mixer of Figure 12 taken along line 13-13.

DETAILED DESCRIPTION

[0031] Figures 1-13 illustrate a ballast water treatment system 10 configured to remove one or more contaminants from ballast water on a vessel. In at least one embodiment, the ballast water treatment system is configured to be used on a vessel, such as a ship, a megayacht, or other vessel that uses ballast tanks to control the level at which a vessel

floats in a water body. Typically, ballast water is taken from the water in which a vessel floats and is stored in ballast tanks. The water often contains contaminants, which may include, but are not limited to, biota, fecal coliform, BODs, CODs, manmade contaminants, and other materials. The ballast water system may remove at least a portion of the contaminants from the ballast water before the ballast water is discharged from the vessel.

[0032] As shown in Figures 1-13, the ballast water treatment system 10 may be formed from modular components adapted for each vessel, and the components may be sized to fit into small compartments commonly found in vessels. In general, the ballast water treatment system 10 may include a filtration system 12 for removing at least a portion of the contaminants from ballast water. The filtration system 12 may filter the ballast water after being drawn from a water body but before the ballast water reaches a ballast water tank 26. The filtration system 12 may also filter the ballast water before the water is discharged from a vessel. The ballast water treatment system 10 may also include a disinfectant injection system 14 for injecting one or more disinfectants into the ballast water. The disinfectant injection system 14 may include one or more disinfectant generators 16 for generating one or more disinfectants from salt water. The byproducts generated by the disinfectant generators 16 may be safely disposed overboard without harm to the environment. The ballast water treatment system 10 may also include an ionized gas injection system 18 for injecting one or more ionized gases into the ballast water to further treat the ballast water. The ionized gas injection system 18 may include one or more ionized gas generators 20 for generating ionized gases. The ballast water treatment system 10 may also include one or more mixers 22 for mixing the ionized gas and disinfectant with the ballast water. Each of these components is described in more detail below.

[0033] As mentioned above, the ballast water treatment system 10 may include one or more filtration systems 12. The filtration system 12 may be formed from a single filter or may be formed from a plurality of filters in at least one embodiment. The filtration system 12 may include a filter 24, as shown in Figures 1 and 2, for removing contaminants from the ballast water. The filter 24 may be formed from various sizes. However, in at least one embodiment, the filter 24 may be a 30 micron to 50 micron filter. The filter 24 may be used to remove particles from water as the water is drawn from a water body and stored in one or more ballast water tanks 26. One or more screens 28, as shown in Figures 1 and 2, may be used upstream of the filter 24 to remove larger contaminants before these large contaminants reach the filter 24 where these contaminants could damage or clog the filter 24. In at least one embodiment, the screen 28 may be capable of filtering out objects 3/8 inch and larger. The filter 24 and the screen 28 may be automatically cleaned at regular intervals or when a programmable logic control system 30 (PLC) of the ballast water treatment system 10 determines that the filter 24 or screen 28 requires cleaning. In at least one embodiment, a differential pressure sensing system 32 may be used to determine whether the filter 24 or screen 28, or both, need to be cleaned.

[0034] The filtration system 12 may also include one or more filters 32, as shown in Figure 1, positioned downstream of the ballast water tank 26. Filter 32 may be identical to filter 24 or may differ. The filter 32 may be positioned upstream of the disinfectant injection system 14 and the ionized gas injection system 18 to prevent contaminants from damaging these systems. While the filter 24 and the screen 28 presumably should filter out contaminants before reaching the ballast water tank 26, it is possible for contaminants to grow in the ballast water tank 26. Thus, some embodiments of the ballast water treatment

system 10 may include filter 32 downstream of the ballast water tank 26. In addition, a screen 34 may be positioned upstream of the filter 32 to remove larger particles so as to prevent damage to the filter 32. Screen 34 may be sized similar or different than the screen 28 upstream of the ballast water tank 26.

[0035] The ballast water treatment system 10 may also include a disinfectant injection system 14. The disinfectant injection system 14 may include one or more disinfectant injectors 40. The disinfectant injector 40 may inject one or more disinfectants into the ballast water. In at least one embodiment, the disinfectant injector 40 may inject one or more disinfectants into the ballast water downstream of the ballast water tank 26 and downstream of the filter 32. The disinfectants may include, but are not limited to, disinfectants derived from saltwater, such as sea water, and may include chlorine, bromine, and other halides. The disinfectants may be stored in a tank or other appropriate device.

[0036] In at least one embodiment, the ballast water treatment system 10 may include a disinfectant generator 16, as shown in Figures 3-5, usable to generate disinfectants. The system 10 may include a single disinfectant generator 16 or multiple disinfectant generators 16 coupled together in series or parallel, or any combination thereof. Multiple disinfectant generators 16 may increase the reduction of contaminants from the ballast water. In this embodiment, a storage tank for the disinfectant is not required, but may be used if desired. Thus, the disadvantages and dangers associated with a storage tank filled with disinfectants may be eliminated when using a disinfectant generator 16. The disinfectant generator 16 may be capable of generating one or more disinfectants from saltwater. The saltwater may be drawn from a water body in which a vessel is floating. In at least one embodiment, as shown in Figure 3, the disinfectant generator 16 may be formed from a housing 42

containing one or more conduits 44 having electrical cells 46 for emitting electricity into the water flowing through the conduits 44. The housing 42 may be generally cylindrical or have another appropriate shape for containing the conduits 44. Likewise, the conduits 44 may be cylindrical or have another appropriate shape. The number of conduits 44 contained in the housing 42 may vary, but housing 42 may contain between four conduits and thirty conduits, and in at least one embodiment, may contain about twenty conduits.

[0037] The housing 42 may also include a header 48, as shown in Figure 5, for distributing saltwater to the plurality of conduits 44. In addition, the disinfectant generator 16 may also include a bypass conduit 52 for controlling the flow of fluid through the conduits 44. In at least one embodiment, one or more valves may be attached to the bypass conduit 52 for regulating flow of fluids through the disinfectant generator 16. Each conduit 44 of the disinfectant generator 16 may operate efficiently at a flow rate between about 5 gallons per minute (gpm) and about 40 pgm. To keep the disinfectant generator 16 operating at this level, the disinfectant generator 16 may pass excess fluids through the bypass conduit 52. The fluids passing through the bypass conduit 52 and the fluids passing through the conduits 44 mix in the header 49 before flowing to downstream components of the ballast water treatment system 10.

[0038] One or more of the conduits 44 may have a valve 56 on an upstream side and a valve 58 on a downstream side of the electrical cell 46 for controlling flow through the electrical cell 46 and enabling replacement of the electrical cell 46 without having to shutdown the entire system 10 during the replacement effort. One or more of the conduits 44 may have one or more electrical cells 46. The electrical cells 46 may emit an electrical current into the saltwater, which promotes electrolysis. Electrolysis may break the bonds in

various compounds and produce free halides, such as but not limited to, chlorine and bromine, in liquid form. The reduction potential for saltwater electrolysis may be as follows:

(1) Electrolysis of Water

$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ 1.229 V;

(2) Potential Halide Reactions

$Cl_2 + 2e^- \rightarrow 2Cl^-$ 1.358 V;

$Br_2 + 2e^- \rightarrow 2Br^-$ 1.065 V;

[0039] The disinfectant generator 16 may be capable of producing halides, such as chlorine and bromine, in a concentration of between about 0.5 parts per million (ppm) and about 20 ppm. The desired amount of disinfectant produced is a concentration large enough to remove biota and other contaminants from the water and have residual concentrations of the chlorine or bromine left over.

[0040] The disinfectants may be collected and sent to a conduit 62 carrying contaminated fluids. Byproducts produced by this process may be returned to the sea or other water body, or other location. The components of the disinfectant generator 16 may be formed from materials, such as, but not limited to, stainless steel, such as stainless steel 316L schedule 40, fiberglass, or bond strand. One or more of the conduits 44 may include one or more sensors 64 for measuring salinity, pressure, temperature, and other system parameters. Sensor 64 is depicted as a tube in Figure 5; however, sensor 64 is not limited to this configuration. The disinfectant generator 16 may also include a water leak detector,

which may send an alert signal in the event of internal piping failure to prevent catastrophic results. A petcock (not shown) may also be included in the housing 42 for manual viewing of the internal aspects of the disinfectant generator 16.

[0041] The ballast water treatment system 10 may also include one or more ionized gas injection systems 18 for injecting one or more ionized gases into the ballast water. The ionized gas injection system 18 may include one or more ionized gas injectors 70 for injecting ionized gas into the ballast water, and more particularly, for injecting ionized gas into the mixer 22. The ionized gas injector 70 may be adapted to inject ionized gases, such as, but not limited to, nitrogen and oxygen, into the mixer 22.

[0042] The ionized gas injection system 18 may also be formed from one or more ionized gas generators 20. As shown in Figures 6-10, the ionized gas generator 20 may be formed from a plurality of chambers 72 containing one or more ultraviolet (UV) lamps 74. The ionized gas generator 20 may include between one lamp and about 20 lamps, with at least one embodiment having about eight lamps as shown in Figure 7. In at least one embodiment, the ultraviolet lamps 74 may emit ultraviolet light having a wavelength between about 185 nm and about 255 nm. The chambers 72 may be, but are not limited to, generally cylindrical tubes sized and adapted to contain a plurality of UV lamps 74. The UV lamps 74 may extend from a first end 76 of the chamber 72 to a second end 78 of the chamber 72, which is generally opposite to the first end 76.

[0043] The ionized gas generator 20 may also have a plurality of magnets 80 positioned in the chambers 72. In at least one embodiment, the magnets 80 may be, but are not limited to, permanent magnets, such as rare earth magnets. The magnets 80 may be positioned, as shown in Figure 8, generally along a longitudinal axis 82 of a chamber 72. Each chamber 72

may include a plurality of magnets 80 stacked on top of each other using spacers 82 and oriented so that ends of adjacent magnets 80 have like polarity. Orientation of the magnets 80 in this manner increases the width of the magnetic field produced by the magnets 80. In at least one embodiment, the width of the magnetic field may be at least as large as the distance between the magnets 80 and an inside surface 86 of the chamber 72. Passing air through the magnetic fields produced by the magnets 80 and exposing the air to ultraviolet light reduces nitrogen and oxygen in the air and produces free oxygen and nitrogen.

[0044] The number of chambers 72 used in a particular application depends on the circumference and length of the chambers 72 and the anticipated fluid flow through the ballast water treatment system 10. In at least one embodiment, as shown in Figure 6, the chambers 72 may have diameters that are about 15 centimeters and may be about 60 inches in length. In this embodiment, as shown in Figure 10, the ionized gas generator 20 may include between about one chamber and about 90 chambers 72; however, the ionized gas generator 20 is not limited to being formed from this number of chambers. Rather, the ionized gas generator 20 may be formed from other amounts of chambers 72. In at least one embodiment, the chambers 72 may be coupled together in parallel. Air flowing through the chamber 72 cools the ultraviolet lamps 74 while being ionized. In at least one embodiment, the air flow rate may be between about two cubic feet per minute (cfm) and about six cfm, depending on the circumference and length of the chambers 72. In one embodiment, the ionized gas generator 20 may have a flow rate of air through the generator 20 of about 2.5 cfm.

[0045] The reduction potential for ionized gas according to the present invention is as follows:

Oxidizing Gas Species

$$O_3 + 2H^+ + 2e^- \rightarrow O_2 + H_2O \qquad 2.07\text{ V;}$$

$$H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O \qquad 1.32\text{ V;}$$

The ionized gas provides both a biological influence and an electromagnetic influence on the water containing the electrolytically produced disinfectants and enhances the coagulation of the contaminants, the separation of solid particles, and the removal of contaminants.

[0046] Ionized gas may be injected into the ballast water through numerous different devices. In at least one embodiment, ionized gases may be injected into the ballast water using injectors while the ballast water is in one or more conduits. In yet another embodiment, ionized gases may be injected into the ballast water in one or more mixers 22. In at least one embodiment, one or more mixers 22, as shown in Figures 11-13, may be positioned downstream of the disinfectant injection system 14. In at least one embodiment, the mixer 33 may be formed from an elongated housing 90 containing a plurality of injectors 92. The injectors 92 may be positioned around the perimeter of the housing 90 and offset relative to each other so as to form a helical formation. However, the position of the injectors 92 is not limited to this configuration. Rather, the injectors 92 may be positioned in other configurations about the housing 90. In at least one embodiment, the injectors 92 may be offset about 76 millimeters and rotated about 45 degrees relative to each adjacent injector 42.

[0047] In at least one embodiment, as shown in Figures 12 and 13, the injectors 92 may include a deflector 94 extending from the housing 90 into inner aspects of the mixer 22. In at least one embodiment, the deflector 94 may be formed from a V-shaped member. Gas may be injected under pressure or drawn in under low pressure created behind the deflector 94 via the Venturri effect. The injector 92 may also include a diffuser 96, which may be,

but is not limited to, a stone, for diffusing a gas into a fluid contained in the mixer 22. The diffuser 96 may be adapted to emit a gas, such as an ionized gas. The ionized gas may be received from an ionized gas generator 20 or another source, such as, but not limited to, a storage tank. The mixer 22 may include gaskets and bolt sleeves in appropriate locations to establish galvanic isolation between dissimilar metals to enhance the life of the mixer 22. In at least one embodiment, as shown in Figure 11, the mixer 22 may be generally cylindrical; however, in other embodiments, the mixer 22 may have other appropriate shapes.

[0048] The ballast water treatment system 10 may also include a recirculation loop 100, as shown in Figure 1, for directing ballast water having one or more contaminants above a selected standard to the beginning of the water treatment system 10 to be sent through the system 10 once again. The standards selected may be those standards of the jurisdiction in which a vessel containing the water treatment system 10 is present.

Operation of the Ballast Water Treatment System

[0049] Operation of the ballast water treatment system 10 may be controlled using various controllers, such as the PLC 30, to automatically control and operate the various components of the ballast water treatment system 10 described above. The controllers for the ballast water treatment system 10 may be completely contained on the vessel in which the ballast water treatment system 10 is mounted. In other embodiments, some or all of the controllers may be located on another vessel, an aircraft, on land, or in another location. Thus, the ballast water treatment system 10 may be controlled by personnel not on the vessel in which the ballast water treatment system 10 is mounted. A configuration such as this

prevents crew members from overriding the system 10 and discharging ballast water having concentrations of contaminants that are greater than applicable regulations. Thus, remote control of the system 10 may prevent an owner of a vessel from being exposed to liability from illegal discharges.

[0050] The ballast water treatment system 10 may be configured from a plurality of modules sized to accommodate an anticipated maximum load from ballast water tanks 26. The ballast water treatment system 10 may utilize one or more of the following: nitrogen, oxygen, bromine, chlorine, hydrogen peroxide, and other chemicals, to disinfect the ballast water. Thus, the ballast water treatment system 10 may treat ballast water without injecting the ballast water with significant amounts of chemicals that are harmful to the environment.

[0051] The ballast water may be drawn from a water source, such as, but not limited to, a water body in which a vessel is floating. Water may be drawn into the vessel using one or more pumps (not shown) and deposited into the ballast water tanks 26. In at least one embodiment, the ballast water may first be passed through a screen 28 to filter out relatively large contaminants. The pumps or conduits, or both, may be configured to cause physical damage to living organisms by subjecting the living organisms to rough surfaces, high or low pressures, or any combination thereof, to distort the shape of the organisms before the organisms pass through a filter. The ballast water may also be passed through a filter 24 for removing a substantial portion of the contaminants. For instance, in at least one embodiment, the filter 24 may remove contaminants about 30 microns in size and larger. The ballast water may then flow into the ballast water tanks 26 until the ballast water is needed to be released from the vessel.

[0052] The ballast water may be treated either when received into the ballast water tank 26 or when released from the ballast water tank 26. In the preferred embodiment, ballast water is treated when released so that any contaminants that may have formed in the ballast water tank 26 may be removed during the treatment process. The ballast water may be mixed with one or more disinfectants. In at least one embodiment, the disinfectant may be a halide taken from sea water and may include, but is not limited to, chlorine or bromine, or both. The disinfectant may be generated by passing salt water through the disinfectant generator 16. The flow of saltwater thorough the conduits 44 may be controlled using the bypass conduit 52 and one or more valves to ensure proper operation. Waste products produced by the disinfectant generator 16 may be disposed overboard. The disinfectant may mix with the ballast water to remove at least a portion of the biota, BODs, CODs, or chemicals, or any combination thereof, or other contaminants from the ballast water.

[0053] The ballast water may also be mixed with one or more ionized gases. The ionized gases may be produced using one or more ionized gas generators 20. In at least one embodiment, air may be passed through the ionized gas generators 20 to generate one or more ionized gases. The ionized gases may be injected into the ballast water through one or more ionized gas injectors 92. In at least one embodiment, the ionized gases may be mixed with the ballast water in a mixer 22. As the ballast water flows through the mixer 22, ionized gases may be injected into the ballast water through diffusers 96 attached to the injectors 92. As the ballast water exits the mixer 22, the concentration of contaminants in the ballast water should be equal to or less than applicable thresholds, thereby enabling the ballast water to be disposed overboard. If the ballast water has contaminant concentrations higher than applicable regulations or chosen threshold, the ballast water may be passed through the

recirculation loop 100 so that the ballast water may be passed through the ballast water treatment system 10 again to attempt to reduce the contaminant concentration. The ballast waste treatment system 10 may be formed from different combinations of the above-identified components depending on the applicable standards.

[0054] The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof. Having thus described the invention in detail, it should be apparent that various modifications can be made in the present invention without departing from the spirit and scope of the following claims.